REMARKS

This communication is in response to the Office Action dated March 27, 2003. Claims 1-14 and 21-33 are pending in the present Application. Claims 1-14 and 21-33 have been rejected. Claims 1 and 21 have been amended for clarification. Claims 32 and 33 have been canceled. Claims 34 and 35 have been added. Claims 1-14 and 21-31 and 34-35 are pending in the present Application.

The present invention includes an electron emitter that may include an n+ region formed above the substrate, in which the n+ region is formed by doping the substrate with electron rich materials. The p region may then be formed by epitaxial growth of p-doped semiconductor layer on top of n+ region. The thickness of the p region is preferred to be less than the diffusion length of the electrons in the p region. When both the n+ region and the p region exist, the hole concentration in the p region may be less than the electron concentration in the n+ region.

102 Rejections

Claims 1-3, 6-8 and 12

For ease of review, Applicant reproduces independent claim 1 herein below:

1. An electron emitter comprising:
a p region;
a dielectric layer formed directly above said p region;
a metallic layer formed directly above said dielectric layer; and
means for emitting electrons through said metallic layer.

The Examiner states:

> **Claims 1-3, 6-8 and 12 are rejected under 35 U.S.C. 102(b) as being anticipated by Nakagawa et al. (5,985,708).**
>
> **Nakagawa et al. teach an electron emitter 41 comprising: a p region 49; a dielectric layer 70 formed above the p region; a metallic layer 71-73 formed above the dielectric layer; means (terminal) for emitting electrons through the metallic; an n+ region 63 formed above a substrate such that the p region is formed within the n+ region; the substrate being below the p region; the p region being formed from a semiconductor; a p electrode formed above and making electrical contact with the metallic layer; an electron concentration level of the n+ region being greater than a hole concentration level of the p region as noted by the plus sign of the n+ region; and an n electrode formed above and making electrical contact with the n+ region (Figures 12-17, cols 16-18, all lines).**

Applicant respectfully disagrees with the Examiner's rejection. The present invention of claim 1 is an electron emitter that includes a p region, a dielectric layer formed directly above said p region, a metallic layer formed directly above said dielectric layer and means for emitting electrons through said metallic layer.

The Examiner asserts that claim 1 is anticipated by the Nakagawa et al. reference. Applicant respectfully disagrees. Nakagawa et al. discloses a semiconductor apparatus comprising a vertical type semiconductor device having a first conducting type semiconductor substrate, a drain layer formed on the surface of the semiconductor substrate, a drain electrode formed on the surface of the drain layer, a second conducting type base layer selectively formed on the surface of the semiconductor substrate opposite to the drain layer, a first conducting type source layer selectively formed on the surface of the second conducting type base layer, a source electrode formed on the first conducting type source layer and the second conducting type base layer, and a gate electrode formed in contact with the first conducting type source layer, the second conducting type base layer and the semiconductor substrate through a gate insulating film.

The present invention of claim 1 has been amended for clarification to include the term ***directly*** with regard to the formation of the dielectric layer 245 and the metallic layer 240, support for which is found in Figure 2A (see attached Exhibit A) of the specification. The word "directly" is defined in the American Heritage® Dictionary of the English Language, Fourth Edition as:

> 1. In a direct manner; in a straight line or course. "To run directly on." –Shak. Indirectly and directly too Thou hast contrived against the very life Of the defendant. – Shak.
> 2. In a straightforward way; ***without anything intervening***; not by secondary, but by direct, means. (Emphasis added.)

Accordingly, the term ***directly***, as utilized in conjunction with the formation of the dielectric layer 245 and the metallic layer 240, implies that there are no intervening elements between the dielectric layer 245 and p region 230 or the dielectric layer 245 and the metallic layer 240.

Based on this embodiment, as well as other recited embodiments, the emitter in accordance with the present invention may emit a high density of electrons. Also, the lifetime of the emitter may be relatively high. Additionally, the detrimental effects of field emitters – cathode surface erosion, ion absorption at the emitter surface, etc. – may be avoided since the device does not require strong electric fields resulting in stable operation. Thus, stability and high current density may be combined in a single device.

In contrast to the present invention, Nakagawa et al. does not disclose a dielectric layer formed ***directly*** above a p region and a metallic layer formed ***directly*** above a dielectric layer. Although Nakagawa et al. does disclose a p region 49, a dielectric layer 70 and a metallic layer 71-73, the dielectric layer 70 is not formed directly above the p region 49 nor is the metallic layer 71-73 formed directly above the dielectric layer 70 as

recited in claim 1 of the present invention (see Figure 18 of Nakagawa et al. attached Exhibit B). As can be seen in Exhibit B, although the dielectric layer 70 is formed above the p region 49, the dielectric layer 70 and the p region 49 are separated by an oxide film 56 and a gate electrode 57. Furthermore, the metallic layer 71-73 is not formed directly above the dielectric layer 70.

Applicant accordingly asserts that since Nakagawa et al. does not disclose a dielectric layer formed ***directly*** above a p region and a metallic layer formed ***directly*** above a dielectric layer, the recited invention of claim 1 is not anticipated by the Nakagawa et al. reference. Consequently, the recited invention of claim 1 is allowable over the Nakagawa et al. reference.

Claims 2-3, 6-8 and 12

Since claims 2-3, 6-8 and 12 are dependent on claim 1, the above-articulated argument with regard to claim 1 applies with equal force to claims 2-3, 6-8 and 12. Accordingly, claims 2-3, 6-8 and 12 should be allowed over this reference.

103 Rejections

Claims 4-5 and 13

The Examiner states:

> **Claims 4-5 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) as applied to claims 1-3, 6-8 and 12 in view of van Gorkom et al. (4,325,084).**

Applicant respectfully disagrees with Examiner's rejection. Since claims 4-5 and 13 are dependent on claim 1, the above-articulated argument with regard to claim 1 applies with equal force to claims 4-5 and 13. Accordingly, claims 4-5 and 13 should be allowed over this reference.

Claim 9

The Examiner states:

> **Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkham et al. (4,325,084) as applied to claims 1-3, 6-8 and 12-13 above in view of Morishita (5,140,400).**

Applicant respectfully disagrees with Examiner's rejection. Since claim 9 is dependent on claim 1, the above-articulated argument with regard to claim 1 applies with equal force to claim 9. Accordingly, claim 9 should be allowed over this reference.

Claim 10

The Examiner states:

> **Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkham et al. (4,325,084) as applied to claims 1-3, 6-8 and 12-13 above in view of Bronner et al. (6,242,770 B1).**

Applicant respectfully disagrees with Examiner's rejection. Since claim 10 is dependent on claim 1, the above-articulated argument with regard to claim 1 applies with equal force to claim 10. Accordingly, claim 10 should be allowed over this reference.

Claim 11

The Examiner states:

Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkham et al. (4,325,084) as applied to claims 1-3, 6-8 and 12-13 above in view of Ishio et al. (US 200/0014705 A1).

Applicant respectfully disagrees with Examiner's rejection. Since claim 11 is dependent on claim 1, the above-articulated argument with regard to claim 1 applies with equal force to claim 11. Accordingly, claim 11 should be allowed over this reference.

Claims 21 and 29

For ease of review, Applicant reproduces independent claim 21 herein below:

21. An electron emitter comprising:

a p region;

a dielectric layer formed directly above said p region;

a metallic layer formed directly above said dielectric layer; and

at least one voltage biasing source electrically connected to said p region and said metallic layer such that electrons pass through said metallic layer.

The Examiner states:

Claim 21 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkham et al. (4,325,084) and Kusunoki et al. (US 2001/0017515 A1) as applied to claims 1-8 and 12-13 above and further in view of Ishio et al. (2001/0014705A1).

Applicant respectfully disagrees with the Examiner's rejection. The present invention of claim 21 is an electron emitter that includes a p region, a dielectric layer formed directly above said p region, a metallic layer formed directly above said dielectric layer and at least one voltage biasing source electrically connected to said p region and said metallic layer such that electrons pass through said metallic layer.

When making a rejection under 35 U.S.C. § 103, a necessary condition is that the combination of the cited references must teach or suggest all claim limitations. If the cited references do not teach or suggest every element of the claimed invention, then the cited references fail to render obvious the claimed invention, i.e. the claimed invention is distinguishable over the combination of the cited references.

It has been shown above (in relation to claim 1), that Nakagawa et al. does not disclose a dielectric layer formed ***directly*** above a p region and a metallic layer formed ***directly*** above a dielectric layer as recited in claim 21. Furthermore, Applicant asserts that the van Gorkam et al., Kushunoki et al. and Ishio et al. references fail to correct the outlined deficiency of the Nakagawa et al. reference. Applicant accordingly asserts that since the Examiner's combined 103 references do not disclose a dielectric layer formed ***directly*** above a p region and a metallic layer formed ***directly*** above a dielectric layer, the recited invention of claim 21 is not taught or suggested by the Examiner's cited references. Consequently, the recited invention of claim 21 is allowable over the Examiner's cited references.

Since claim 29 is dependent on claim 21, the above-articulated argument with regard to claim 21 applies with equal force to claim 29. Accordingly, claim 29 should be allowed over the Examiner's cited references.

Claims 14-17, 20, 24-25, 28 and 32-33

The Examiner states:

> **Claims 14-17, 20, 24-25, 28 and 32-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkom et al. (4,325,084) as applied to claims 1-8 and 12-13 in view of Kusunoki et al. (US 2001/0017515 A1).**

Applicant respectfully disagrees with Examiner's rejection. Firstly, Applicant asserts that claims 15-17, 20 and 32-33 have been canceled. Secondly, since claim 14 and claims 24-25 and 28 are respectively dependent on claims 1 and 21, the above-articulated arguments with regard to claims 1 and 21 apply with equal force to claims 14, 24-25 and 28. Accordingly, claims 14, 24-25 and 28 should be allowed over these references.

Claims 18 and 26

The Examiner states:

Claims 18 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkom et al. (4,325,084) and Kusunoki et al. (US 2001/0017515 A1) as applied to claims 1-8 and 12-13 above, and further in view of Morishita (5,140,400).

Applicant respectfully disagrees with Examiner's rejection. Firstly, Applicant asserts that claim 18 has been canceled. Secondly, since claim 26 is dependent on claim 21, the above-articulated arguments with regard to claim 21, apply with equal force to claim 26. Accordingly, claim 26 should be allowed over these references.

Claims 19 and 27

The Examiner states:

Claims 19 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkom et al. (4,325,084) and Kusunoki et al. (US 2001/0017515 A1) as applied to claims 1-8 and 12-13 above, and further in view of Bronner et al. (US 6,242,770 B1).

Applicant respectfully disagrees with Examiner's rejection. Firstly, Applicant asserts that claim 19 has been canceled. Secondly, since claim 27 is dependent on claim 21, the above-articulated arguments with regard to claim 21, apply with equal force to claim 27. Accordingly, claim 27 should be allowed over these references.

Claims 22 and 30

The Examiner states:

> **Claims 18 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkom et al. (4,325,084) and Kusunoki et al. (US 2001/0017515 A1) as applied to claims 1-8 and 12-13 above, and further in view of Morishita (5,140,400).**

Applicant respectfully disagrees with Examiner's rejection. Since claims 22 and 30 are dependent on claim 21, the above-articulated arguments with regard to claim 21, apply with equal force to claims 22 and 30. Accordingly, claims 22 and 30 should be allowed over these references.

Claims 23 and 31

The Examiner states:

> **Claims 23 and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakagawa et al. (5,985,708) and van Gorkom et al. (4,325,084) as applied to claims 1-8 and 12-13 above, and further in view of Song (6,153,014).**

Applicant respectfully disagrees with Examiner's rejection. Since claims 23 and 31 are dependent on claim 21, the above-articulated arguments with regard to claim 21, apply with equal force to claims 23 and 31. Accordingly, claims 23 and 31 should be allowed over these references.

New Claims

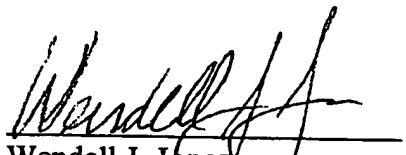
With this response, claims 34 and 35 have been added. Claim 34 is an independent claim. Independent claim 34 recites "...a dielectric region formed directly above said p region..." and "a metallic layer formed directly above said dielectric region". It has been shown above that none of the cited references teaches or suggests these features. Therefore, independent claim 21 is allowable over all cited references, individually or in any combination.

Since claim 35 is dependent on claim 34, the above-articulated argument with regard to claim 34 applies with equal force to claim 35. Accordingly, claim 35 should be allowed over the cited references.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned "Version with markings to show changes made."

Applicant believes that this application is in condition for allowance. Accordingly, Applicant respectfully requests reconsideration, allowance and passage to issue of the claims as now presented. Should any unresolved issues remain, Examiner is invited to call Applicant's attorney at the telephone number indicated below.

Respectfully submitted,



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Respectfully submitted,

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VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

1. (Twice Amended) An electron emitter comprising:

a p region;

a dielectric layer formed directly above said p region;

a metallic layer formed directly above said dielectric layer; and

means for emitting electrons through said metallic layer.

21. (Amended) An electron emitter comprising:

a p region;

a dielectric layer formed directly above said p region;

a metallic layer formed directly above said dielectric layer; and

at least one voltage biasing source electrically connected to said p region and said metallic layer such that electrons pass through said metallic layer.

30. (Amended) The electron emitter according to claim 21, wherein a thickness of said dielectric layer is such that a dielectric breakdown field F_b of said dielectric layer substantially meets the condition $F_b \geq 1.5 * 10^7$ V/cm [$1.5 * 10^7$ V/cm $\leq F_b \leq 2 * 10^7$ V/cm].

31. (Amended) The electron emitter according to claim 21, wherein a thickness of said dielectric layer is such that a dielectric breakdown field F_b of said dielectric layer substantially meets the condition $F_b \geq 1.5 * 10^7$ V/cm [$1.5 * 10^7$ V/cm $\leq F_b \leq 2 * 10^7$ V/cm].

Cancel claims 32 and 33.

34. (New) An electron emitter comprising:

a p region wherein an acceptor hole concentration in the p region ranges substantially between $10^{16}cm^{-3}$ and $10^{18}cm^{-3}$;

a dielectric region formed directly above said p region wherein a thickness of said dielectric region ranges substantially between 1.5 nanometers and 2.0 nanometers and wherein a dielectric breakdown field F_b of said dielectric region substantially meets the condition $F_b \geq 1.5 * 10^7$ V/cm wherein said dielectric region is formed from materials including at least one of SiO_2, Al_2O_3 and alloys thereof;

a metallic layer formed directly above said dielectric region wherein a thickness of said metallic layer is less than a range of between 2.0 nanometers and 5.0 nanometers wherein said metallic layer is formed from materials including at least one of Au, Ag, Al, Gd, W, Pt, Ir, Pd and alloys thereof;

a substrate below said p region; and

at least one voltage source electrically connected between said p region and said metallic layer such that electrons pass through said metallic layer.

35. (New) The electron emitter according to claim 1, further comprising

an n region formed above said substrate such that said p region is formed above said n region wherein a donor concentration of said of said n region is greater than the acceptor hole concentration; and

at least one voltage source electrically connected between said n region and said metallic layer.